PHASE I: CONCEPT EXPLORATION

Step 5.0 Define Requirements for HF/S Analyses, Studies and Assessments

Objective: HF/S studies and analyses are conducted to: 1) provide a better understanding of HF/S requirements, 2) complete the description of HF/S concepts and strengths and weaknesses of specific concepts, and 3) support design decisions and development of design and tradeoff criteria.

Inputs: Needs for HF/S inputs to acquisition and procurement documentation.

Outputs: Results of HF/S analyses

5.1 Define Requirements for HF/S Analyses, Studies and Assessments

5.1.1 Conduct Modeling and Simulation and Design Studies

- Identify requirements for analytic studies
  - Identify objectives of analytic studies
    - integration and prioritization of requirements and constraints
    - assess feasible alternative human factors concepts
    - assess human factors issues inherent in selected system level concepts
    - develop design decisions associated with each alternative human factors concept
    - identify human factors issues associated with supportability requirements for selected system concepts
  - Identify requirements for analytic studies
    - Conduct requirements analysis
    - Conduct human performance capability analysis
    - Develop operational models
    - Complete development of concepts
    - Conduct error likelihood analysis
    - Conduct link analysis
    - Conduct arrangements analysis
    - Conduct environmental effects analysis
    - Conduct speech intelligibility analysis
    - Conduct coding requirements analysis
    - Conduct alarm requirements analysis
    - Conduct role-of-man versus automation analysis
- Identify requirements for evaluation studies
  - Identify objectives of evaluation studies
    - evaluate human factors aspects of predecessor and baseline systems
    - evaluate system configurations for selected system concepts
    - evaluate arrangements and equipment layout concepts

- Identify requirements for evaluation studies
    - conduct evaluation of predecessor/baseline systems
    - conduct evaluation of existing system configuration
        - drawings
        - mockups
        - breadboards
        - engineering models
        - actual hardware
        - software products
        - training effectiveness
        - evaluate operations in the field environment
- Identify requirements for experimental studies
    - Identify Objectives of experimental studies
        - studies designed to satisfy unresolved issues/problems
        - investigations of human performance levels associated with alternative human factors concepts
        - studies of specific design approaches
        - man-computer interface studies
        - environmental effects studies
    - Identify requirements for experimental studies
        - conduct human performance investigations
        - conduct human reliability measurements
        - assess alternate concepts
        - assess display characteristics (e.g., symbology)
- Identify requirements for HF/S simulation studies
    - Identify Objectives of simulation studies
        - Assess human performance, productivity, workload, and safety using a logical or virtual representation of the system, equipment, and environment before finalizing design decisions and directions;
        - Provide human performance inputs to system level simulation, and determine the impact of system design and organization on human performance and safety;
        - Quantify relationships between human capabilities, operational variables, and design concepts for workload, visual fields, arrangements, traffic patterns, personnel interactions, display, maintenance access, etc.;
        - Visualize and quantify spatial relationships between humans and workstations, worksites, spaces, equipment, and environments.
    - Identify levels of HF/S simulation studies and expected results
        - Models of human interaction in system functions
            - Workload Assessment - workload quantification
            - Diagnostic Problem Solving - Reduction of Uncertainty
            - Rehearsal - Playout of Expected Scenarios
            - Mission Planning
            - Predictive "What-If" Simulation
            - System Level Performance Assessment
        - Single human-in-the-loop - single operator performing tasks with a representation of system human interfaces - controls, displays, workstation elements, information, environments. Usually the arrangement in virtual reality representations. Results - Concepts and Criteria for:

        - Human Performance as a function of Human Machine Interface (HMI) design concepts
        - Human Interaction with Automation - Decision Support
        - Teleoperation - Telemaintenance
        - Workload Measurement - Dynamic Allocation of Functions
        - Information Management
    - Several humans-in-the-loop: simulation with one real and several simulated participants, or several real human participants performing mission tasks as in 2) above. Results: Concepts and Criteria for:
        - Team Performance as a function of HMI Design
        - Communications design and protocols
        - Collaborative/Cooperative Problem Solving
        - Impact of Stress on Human Performance
    - Single Human Model or Mannequin observed to perform tasks at a workstation or worksite with emphasis on visualization of reach envelope, field of view or visual envelope, control and display placement, workstation anthropometrics, etc. Results - Design Concepts and Criteria for:
        - Physical Interactions with Arrangements
        - Visual - Reach Envelopes
        - Maintenance Access
        - Emergency Egress
        - Watchstation arrangement and orientation
    - Multi-Human Models or Mannequins (physical or virtual) observed to perform tasks in a simulated environment where the emphasis is on visualization of arrangements, layouts, queuing, interactions. Results - Concepts and Criteria for:
        - Aircraft Servicing
        - Multi-Person Maintenance Activities
        - Deck Operations
        - Space Arrangements - Multi Watchstations
        - Traffic Patterns - Cargo Transfer
    - A combination of several human operators and several simulated operators performing tasks involving real and simulated systems and platforms, under real and simulated environmental conditions, conditions of readiness, and mission requirement conditions. Results:
        - Full Mission Simulation
        - Total CG system Training Simulation
- Select type of simulation for each level
    - *Analytical Simulation*- for mission, function, task, workload, timeline analyses; tradeoff analysis; and design requirements integration.
    - *Diagnostic Simulation*- - playout of alternate scenarios for purposes of supporting decision making and diagnostics.
    - *Engineering simulation* - to support development and evaluation of design concepts and approaches.
    - *Training simulation* - to support training delivery, rehearsal of learned skills , and interactive gaming.
    - *Demonstration simulation* - visualization of concepts to demonstrate feasibility and risk reduction.
    - *Planning/gaming simulation*

- Identify requirements for simulation studies
  - Acquire Human Performance and Workload Data;
  - Assess alternate Function Allocation/Role of the Human vs Automation Strategies;
  - Conduct Evaluations of Alternate Design Approaches for Human-Machine Interfaces (HMI);
  - Design of M&S HMI for Usability;
  - Assess Alternate Interactions with Automation;
  - Assess Design Approaches for Decision Support Systems;
  - Select type of simulation
    - part task simulation studies
    - full task simulation studies
    - conduct walkthroughs - predecessor systems
    - Develop Experimental Design - Ensure Quality of Data

- Prepare experimental design
  - Identify Independent Variables
    - alternative designs/concepts/variants
    - levels of automation
    - function allocation/role of human strategies
    - technology capability assumptions
    - factors to ensure high data relevance
  - Identify Dependent Variables
    - Measures of Effectiveness - e.g. information bottlenecks
    - Measures of Performance - e.g. time and accuracy
    - Workload Measures - e.g. Time on tasks
    - Productivity Measures - throughput
  - Identify Control Variables
    - factors to ensure fidelity to the real world
    - factors to ensure high data reliability
    - factors to ensure high data validity
    - specification of simulation initial conditions
    - specification of simulation test conditions
    - specification of simulation terminal conditions
  - Prepare experimental software and facilities
  - Prepare study plan
  - Conduct studies and analyses
  - Analyze and Interpret data and prepare study report
  - Integrate study results
    - identify inconsistencies/incompatibilities in study results
    - identify dependencies among requirements based on study results
    - identify common requirements for data
    - Prioritize HF/S study findings in terms of:
      - expected impact on system design
      - expected impact on system effectiveness and readiness
      - expected impact on supportability
      - expected impact on human performance and safety
      - expected impact on system acquisition costs
      - expected impact on life cycle costs

5.1.2 Identify analyses, studies and assessments to be conducted to provide inputs to acquisition documentation

5.1 3 Identify analyses, studies and assessments to support the derivation of HF/S inputs to alternative concepts to be assessed in Phase I

- identify alternative approaches for the role of the human in the operation and maintenance of the system for each design alternative.
- provide HF/S assessment and tradeoff of design alternatives.
- identify workload requirements and state workload sources for each alternative concept.
- define requirements for new occupational specialties and high quality personnel for each alternative concept.
- identify training requirements and assess expected effectiveness of training systems for each alternative concept.
- summarize results of HF/S studies, analyses, and tradeoffs of alternative design concepts.
- provide HF/S inputs to life cycle costs for each alternative concept.
- describe how HF/S lessons learned will be applied for each alternative concept.
- identify and manage HF/S cost, schedule, and design risk areas for each alternative concept.
- incorporate HF/S considerations into the acquisition strategy for each alternative concept.
- identify personnel requirements for operators and maintainers for each alternative concept.
- identify HF/S test and evaluation requirements for each alternative concept.

5.2 Conduct Workload/Manning Analysis

5.2.1 Describe the system concept and manning/role of human concept being assessed

5.2.2 Develop a sequence of tasks to describe activities performed with the concept

5.2.3 Develop workload reduction options

- investigate alternate workload/skill reduction options, such as cross training, automation of manual operations, improved design, and changes in policy and doctrine
- identify task sequences where workload/skill reduction is feasible and potentially beneficial
- select promising workload/skill reduction approaches

5.2.4 Conduct Workload Analyses (using task network simulation)

- Determine workload levels for each position under each condition of readiness and selected operational scenarios
- Identify workload overload and underload problems
- Redistribute workloads
- Conduct workload, manning and performance simulations

5.2.5 Identify the implications of each system concept and manning/role of human concept

5.2.6 Identify and describe feasible manning/workload reduction concepts

5.3 Conduct skills/training analysis

5.3.1 Develop Manning and skill estimates

- review task analysis data
- identify the LSAR manning levels by tasks
- identify skill requirements by tasks
  - job performance knowledge
  - job performance skills
- integrate manning and skill requirements across task sequences

5.3.2 Conduct Analyses to Identify Training Device Requirements and Resources

- identify training system requirements in terms of
  - training objectives
  - training method requirements by training objectives
  - training measurements requirements by training objectives
  - training material requirements by training objectives
  - training media requirements by training objectives
  - training management requirements
- identify training device design requirements
  - training objectives addressed
  - information reception media
  - skills acquisition media
  - fidelity levels
  - display formats
  - range of conditions
  - use of augmented feedback
  - use of prompting and cueing
  - use of branching-programming
  - degree of flexibility to different system configurations
  - data acquisition and recording requirements
  - embedded training requirements
- review training devices approaches implemented in predecessor/baseline systems
- identify problems with existing training devices for selected training objectives
- conduct studies and analyses to develop training device concepts

5.3.3 Describe alternative training device concepts

- conduct tradeoffs of alternative concepts
- integrate selected concepts across training objectives

5.3.4 Develop training device design criteria

5.4 Conduct maintenance analysis

5.4.1 Scope: This analysis addresses maintainer tasks and task requirements and requirements associated with design of maintainer - machine interfaces. These include:

- workspace design and layout;
- LRU design for accessibility,
- removal/replacement, and handling;
- diagnostic display design;
- design of alerts and alarms;
- technical documentation accessibility,
- readability and usability;
- new maintenance skills;
- maintenance training methods, materials and media requirements.

5.4.2 Documentation: The human factors DAD - M document will receive inputs from Data Sheet A, operations and maintenance requirements, and expected maintenance workloads. The human factors DID document will also receive inputs from Data Sheet B, item reliability and maintainability characteristics, specifically: mean time to repair estimates; maintainability considerations; failure modes, effects and criticality data; failure symptoms; task analysis results; and the maintenance concept. The human factors DAD- M document will provide inputs to:

- Data Sheet C -task analysis summary, specifically:
  - skill specialty codes
  - task duration estimates
- Data Sheet D - maintenance and operator task analysis
  - sequential task descriptions
  - task work areas
  - equipment accessibility requirements
  - identified maintainer-machine interfaces
- Data Sheet E-support and test equipment or training material description and justification
  - drawings or photographs of each equipment having a maintainer interface
  - equipment installation requirements
  - technical documentation requirements
  - diagnostic readout requirements
  - additional skill requirements
  - installation factors-constraints for accessibility
  - maintenance procedures and decision criteria
- Data Sheet G -skill evaluation and justification
  - revised skills -by duty position
  - additional skill requirements
  - physical and mental requirements
  - educational qualifications
  - additional training requirements.

5.4.3 Define Maintainability Design Requirements

- review LSA maintenance data and requirements
- identify each item of equipment requiring maintenance
  - specify as organizational or intermediate
  - specify maintenance actions required
  - identify requirements associated with the conduct of maintenance actions
- complete maintenance task analyses for selected items
- develop maintainability design requirements
  - maintenance information requirements
  - design for accessibility
  - equipment arrangement to facilitate maintenance
  - procedures-number and simplicity
  - troubleshooting diagnostics and decisions
  - skill levels and maintenance training
  - equipment design for maintainability
  - allocation of maintenance responsibility to man or machine
  - equipment installation requirements
  - requirements for special tools and support equipment
  - job aid requirements
  - communication requirements
  - facility design requirements
  - safety design requirements

5.4.4 Conduct Analyses to Develop Maintainability Design Concepts

- identify maintainability design approaches in predecessor/baseline systems
- identify maintainability design problems from the fleet feedback system
- conduct studies and simulations
  - to resolve human performance issues
  - to develop maintainability design concepts
  - to evaluate concepts
- develop human factors design concepts
  - equipment design concepts to facilitate maintenance
  - maintenance information concepts
  - role-of-man versus automation concepts
  - job performance aiding concepts
  - facility design concepts to facilitate maintenance
- conduct tradeoffs-select concepts
- integrate selected concepts across maintenance requirements

5.4.5 Conduct Analyses to Support Development of Maintainability Design Criteria

- develop human factors maintainability design criteria
- prepare LSAR inputs
- prepare the human factors design approach document-maintainability

5.4.6 Conduct analyses and studies to support the development of design requirements and approaches for:

- annunciators and alarms
- fault detection
- fault diagnosis
- troubleshooting decision aiding
- removal/replacement
- test, measurement, and diagnostic equipment
- built in test and automatic test equipment
- tool and test sets
- equipment identification and marking

5.4.7 Conduct analyses to establish the role of man vs automation in maintenance activities

5.4.8 Develop design requirements for maintenance access and workspace

5.4.9 Develop design requirements governing equipment arrangements

5.4.10 Assess maintainer error potential and develop approaches to reduce the likelihood of error

5.4.11 Assess potential time to repair problems and develop approaches to reduce the MTTR

5.4.12 Conduct analyses to integrate maintainability design requirements and approaches

5.5 Provide HF/S inputs to Risk Management - HF/S methods, tools and data are focused on efforts to identify, prioritize, and reduce cost risks, schedule risks, design risks, and technology risks. The activities in this realm address reduction of risk, and the conduct of tradeoffs.

5.5.1 HF/S Risk Assessment involves identification of critical human system factors in design alternatives that will have a significant impact on readiness, life cycle costs, schedule, or performance. These include:

- tasks,
- task sequences,
- task complexity estimates;
- environments and environmental controls;
- equipment design features;
- maintenance requirements;
- information requirements;
- user-computer interface features;
- manning requirements;
- workloads;
- personnel skill levels;
- training requirements;
- hazards.

5.5.2 HF/S tradeoff decisions are required at each milestone. At Milestone I the HF/S tradeoffs include:

- role of man vs automation;
- design, manning, or training approaches to reduce high drivers;

- alternative man-machine interface design concepts;
- hazard elimination, guarding, warning, or training;
- training vs job aiding;
- required skill levels of personnel;
- school house training vs organic training;
- training media-fidelity/cost tradeoffs.

5.5.3 The HF/S thrust in risk management is to identify HF/S risks in alternative design concepts, and to determine the requirements for reducing these risks to an acceptable level.

5.5.4 Identify technology risks

- Review alternative system operational and support concepts
- Review anticipated operator and maintainer tasks associated with alternative technology concepts
- Identify HF/S requirements associated with tasks identified for alternative technologies for specific tasks which impact on requirements for HF/S technologies.
- Identify the state-of-the-art HF/S technology
    - Identify the state-of-the-art technology to support the design for fightability
        - target designation techniques
        - predictive displays
        - situation displays
        - integrated displays
        - navigation displays
        - integrated test and training techniques
        - concepts for enhancing visual envelopes
        - special sensors
        - battlefield management display systems
        - communications systems and devices
        - expert systems for command and control
        - Identify the state-of-the-art technology to support the design for operability
            - standard workstations
            - workload distribution/measurement techniques
            - task allocation aids
            - controls and controllers
            - data entry and designation techniques
            - display techniques
            - human-computer interface techniques
            - equipment arrangement aids
            - robotics interfaces
            - design review techniques
            - expert decision systems
        - Identify the state-of-the-art technology to support the design for maintainability
            - expert troubleshooting systems
            - design for accessibility techniques
            - role of the human in automated testing techniques

- documentation techniques
- advanced alarm systems and techniques

- Identify the state-of-the-art technology to support the design for supportability
  - inventory control techniques
  - packaging techniques
- Identify the state-of-the-art technology to support the design for survivability
  - damage control systems
  - protective equipment
  - advanced alarms
  - nutrition and rest techniques
- Identify the state-of-the-art technology to support the design for habitability
  - design techniques to support sustained operations
  - environmental control techniques
  - packaging techniques
- Identify the state-of-the-art technology to support the design for transportability
  - tiedown methods
  - monitoring methods
- Identify the state-of-the-art technology to support the design for erectability/ installability
  - advanced fasteners and connectors
  - simplified assembly instructions
- Identify the state-of-the-art technology to support the design for safety
  - hazard identification techniques
  - warnings and alarms
  - facility design for emergency egress
- Identify the state-of-the-art technology to support the design for usability
  - user-computer interface prototyping techniques
  - advanced workstations
  - on-line help, prompting, cueing
  - intelligent decision aiding e.g. intelligent tutorial, operator's associate
- Identify the state-of-the-art technology to support the design of training systems and devices
  - part task trainers
  - embedded training

- Identify Technology Development Requirements
  - Review NDI and product improvement (PI) as alternatives to technological development
  - PI is made to a system for such reasons as HF/S, operational effectiveness, cost reduction, RAM, deficiency correction, and interoperability. The PI program (PIP) offers the following benefits:
    - provides an alternative to NDI procurement or initiation of new development programs
    - can be used to correct inherent design discrepancies, reduce O&S cost, improve readiness, increase safety, and expand system capability
  - NDIs include materiel developed and in use by U.S. military services or government agencies, allies, or available commercially. NDI decisions must

comply with HF/S, quality, performance, reliability, supportability, transportability, and availability characteristics of the system. The two general categories of NDI are:

- Category A-- off-the-shelf items to be used in the same environment for which it was designed.
- Category B-- off-the-shelf items to be used in an environment different from that for which it was designed.

- For a complete description of HF/S issues and activities in development/ selection of NDI
- Identify High-Risk Areas
  - Develop criteria for determining if a technology requirement is high risk. A technology can be designated high-risk if: any of the following conditions apply:
    - its implementation requires a major breakthrough;
    - its development to the point of transition requires an inordinately high level of funding support;
    - its implementation depends on other technology which is high risk.
  - Identify HF/S and technological high risk areas
  - Identify High-Risk Alternatives
    - Assess alternative technologies
    - Compare the alternative technologies with the high risk criteria
    - Compare the risks associated with alternative technologies with the high risk areas in step 15.3
    - Identify alternatives to the high risk technologies

5.5.5 Identify Risk Assessment Requirements

- Review alternative system operational and support concepts
- Review anticipated operator and maintainer tasks associated with alternative concepts
- Conduct a Comparability Analysis to Identify High Drivers in terms of MPT, human performance & safety, and costs
- Describe each alternative in terms of requirements for manufacturing, support, cost, schedule, and design factors

5.5.6 Identify/Assess Cost Risks

- Review alternative system operational and support concepts
- Identify risks due to operational manning levels
- Identify risks due to maintenance manning levels
- Identify risks due to training costs
- Identify risks due to requirements to redesign to satisfy user needs
- Identify risks due to extended down time/system non-availability
- Identify risks due to excessive time to repair
- Identify risks due to excessive supportability requirements
- Identify risks due to excessive accident rates
- Identify risks due to excessive personnel non-availability
- Integrate/assess cost risks

        - Review risks
        - Determine impact of individual risks
        - Prioritize risks
        - Summarize risks for each alternative

5.5.7 Identify/Assess Schedule Risks

- Review alternative system operational and support concepts
- Id risks due to non-availability of data
- Id risks due to non-availability of tools and methods
- Id risks due to non-availability of resources
- Id risks due to non-availability of technology
- Integrate/assess schedule risks
    - Review risks
    - Determine impact of individual risks
    - Prioritize risks
    - Summarize risks for each alternative

5.5.8 Identify/Assess Design Risks

- Review alternative system operational and support concepts
- Identify human performance risks for each alternative - tasks/conditions with an alternative which:
    - increase the likelihood of human error.
    - make human error difficult to detect.
    - make human error difficult to correct.
    - are at or beyond human physical performance capabilities.
    - are at or beyond human cognitive performance capabilities.
    - contribute to excessive workloads.
    - contribute to inadequate productivity.
    - contribute to unsatisfactory team performance/interaction.
- Identify safety and health hazard risks associated with each alternative
    - Identify tasks/conditions with an alternative which increase the likelihood of accidents.
    - Identify tasks/conditions with an alternative which increase the likelihood of health hazards.
    - Identify tasks/conditions with an alternative which increase the likelihood of psychological stress.
    - Identify tasks/conditions with an alternative which increase the likelihood of physiological stress.
    - Identify tasks/conditions with an alternative which increase the likelihood of physical stress (e.g. extreme exertion, cramped environment)
    - Identify tasks/conditions with an alternative which increase the likelihood of dealing with environmental constraints
    - Identify tasks/conditions with an alternative which increase the likelihood of dealing with unsafe operating, test, maintenance and emergency procedures
    - Identify tasks/conditions with an alternative which fail to take in to account

        life support requirements and their safety implications
        - Identify tasks/conditions with an alternative which increase the likelihood of dealing with unsafe facilities and support equipment
        - Identify alternative design concepts which do not provide safety-related equipment, safeguards, and possible alternate approaches such as interlocks, system redundancy, subsystem protection, fire suppression systems, personal protective equipment, industrial ventilation, and noise or radiation barriers
    - Id risks due to human error
    - Id risks due to expected accident rates
    - Id risks due to unacceptable performance levels
    - Id risks due to expected inadequate productivity
    - Id risks due to expected ineffective training
    - Id risks due to expected excessive workloads
    - Id risks due to inadequate function allocation
    - Id risks due to excessively complex tasks
    - Id risks due to expected health hazards
    - Integrate/assess design risks
        - Review risks
        - Determine impact of individual risks
        - Prioritize risks
        - Summarize risks for each alternative

- 5.5.9 Provide HF/S input to the Risk management Plan
- The purpose of the RMP is to develop a structured approach to
- managing program risks.
- At a minimum, the RMP shall:
    - specify management strategies for each risk element;
    - assess the possible negative impacts of each risk element (or aggregation of risk elements) on the program;
    - specify the cost of the management strategies for each risk element.
- The plan shall address critical parameters that are design cost drivers or have a significant impact on readiness, capability, and life cycle costs. These parameters shall be identified early and managed intensively.
- The plan shall address how test and evaluation shall be used to determine system maturity and to identify areas of technical and operational risk.
- The plan shall identify how solicitation documents will be structured to require contractors to identify risks and specify plans to assess and eliminate risks or reduce them to acceptable levels.
- Summarize cost, schedule, and design risks resulting from HF/S factors
- Highlight current human system cost drivers, MPT drivers, performance and safety high drivers
- Discuss major cost, schedule, and performance tradeoffs
    - HF/S Tradeoffs include:
        - Role of man vs automation
        - aiding, automation, or cross-training
        - Design, manning, or training approaches to reduce high drivers
        - Alternative man-machine interface design concepts

      - Hazard elimination, guarding, warning, or training
      - Training vs job aiding
      - required skill levels of personnel
      - School house training vs organic
      - Training media-fidelity/cost tradeoffs
      - Use of advanced technology vs state-of-the-art

5.6 Conduct HF/S Tradeoffs

5.6.1 Define tradeoff criteria

- Review HF/S Measures of Effectiveness for candidate tradeoff criteria
- Review HF/S issues and lessons learned from predecessor systems to select factors which should be considered in tradeoffs
- Identify HF/S cost, schedule, and design risk areas.
- Select a set of tradeoff criteria to be used in tradeoffs
- system design for fightability
  - time to detect and range at detection
  - first round accuracy subsequent round accuracy projected rate of fire
  - expected target engagement performance
  - expected performance throughout graceful degradation
  - expected performance of battlefield management activities
  - expected performance of command and control activities
  - expected performance of surveillance activities
  - expected performance of damage assessment
  - adequacy of the design for fightability
- system design for operability
  - adequacy of communications
  - workloads associated with operations
  - projected error occurrence rates
  - expected effects of errors
  - projected error recovery rates
  - expected information handling performance
  - human-machine interface design compliance with standards
  - effects of sustained performance
  - adequacy of the design for operability
- system design for maintainability
  - expected fault detection performance
  - expected fault isolation - troubleshooting performance
  - expected accessibility design
  - adequacy of the design for maintainability
- system design for safety
  - expected hazards
  - adequacy of the design to remove hazards
  - adequacy of guards
  - adequacy of warnings and instructions
  - adequacy of the design for safety
- system design for habitability

        - workspace free volume
        - environmental effects
        - traffic patterns
        - workspace layout
        - facility compartmentalization
        - adequacy of the design for habitability
    - system design for survivability
        - availability/adequacy of protection systems and devices
        - expected human performance wearing protective ensembles
        - adequacy of countermeasures
        - adequacy of the design for survivability
    - system design for supportability
        - adequacy of system documentation
        - adequacy of spares access
        - adequacy of the design for supportability
    - system design for portability/transportability
        - ease of carrying
        - expected weight and weight distribution
        - time and effort involved in preparing for transport
        - expected performance in monitoring system condition during transport
        - adequacy of the design for portability/transportability
    - system design for erectability/installability
        - time and accuracy in setting up
        - expected performance in making and mating subassemblies
        - expected performance in positioning/emplacing
        - adequacy of the design for erectability/installability
    - system design for usability
        - expected operator/user problems
        - expected user productivity
        - user-computer interface design compliance
        - extent to which the user can navigate through the software
        - extent to which the user is helped, tutored, cued or prompted
        - cognitive workload associated with operations
        - adequacy of system response time
        - likelihood of user errors
        - adequacy of the design for usability
    - personnel availability
        - adequacy of manning levels
        - requirements for special skills
        - adequacy of workloads and workload distribution
        - evaluation of personnel utilization
        - adequacy of the assigned role of man vs. automation
    - personnel training
        - projected training effectiveness
        - training pipeline measures
        - cost of training
    - health hazards
        - hazards and severity rates

    - adequacy of protection systems
    - incidence of fatigue
    - incidence of biomedical problems
  - Integrate selected tradeoff criteria

5.6.2 Describe alternative HF/S design/readiness concepts

- Review already defined design/readiness concepts
- Describe each design/readiness concept
- Identify variants of each concept which themselves become additional concepts

5.6.3 Prioritize tradeoff criteria

- Establish the weighting scale
- Describe the meaning of each scaling unit
- Assign scaling weights to tradeoff criteria

5.6.4 Define concept characteristics

- Define the distinguishing characteristics of each concept
- Define the characteristics of each concept most important from a HF/S point of view

5.6.5 Conduct tradeoffs

- Summarize strengths and weaknesses of alternate concepts based on tradeoff results
- Integrate strength and weakness data for each concept
- Identify additional alternative concepts to be assessed

5.7 HF/S inputs to the Affordability Assessment

5.7.1 The issue of affordability takes center stage in the HF/S processes due to the importance of workload, personnel and training as drivers of life cycle costs, and due to the importance of reducing human error, the leading cause of accidents and system failures.

5.7.2 HF/S inputs to the Affordability Assessment include the results of assessments of the implications of HF/S for each candidate Acquisition Strategy and Alternative Design Concept. This analysis involves determination of life cycle resource requirements for:

- operational and maintenance workload;
- training;
- personnel non-availability due to accident;
- expected human error rates;
- expected time to repair;
- requirements for supportability;
- requirements resulting from expected system downtime.

5.7.3 The Affordability Assessment will also determine if the proposed acquisition strategy is in line with Defense Planning Guidance and long-range modernization and investment plans. The Assessment will define the adjustments required of the proposed acquisition strategy due to HF/S affordability factors; and will recommend changes to the acquisition strategy, or alternative acquisition strategies to resolve problems due to HF/S affordability factors. The Affordability Assessment will assess alternative design concepts on HF/S affordability factors, will identify alternative design concepts having problems with HF/S affordability factors; and will recommend changes to alternative design concepts to improve the performance of HF/S affordability factors.

5.7.4 Provide HF/S inputs to the Cost benefit Analysis (CBA)

- The CBA analyzes the relationship between the life cycle cost and the operational effectiveness of a concept/ alternative which is technically feasible and can meet the mission need. The purpose of each analysis is to:
  - aid decision-making by clearly indicating the relative advantages and disadvantages of the concepts/alternatives being considered and the sensitivity of each concept/alternative to possible changes in key assumptions;
  - facilitate communications by early identification and discussion of reasonable concepts/alternatives among decision makers and staffs at all levels; and
  - document acquisition decisions by providing the analytical underpinning or rationale for decisions on a program.
- Contents of the CBA - procedures must include the following
  - Mission Need Analysis. Concepts/alternatives must be assessed to identify what operational capabilities would be gained (or foregone) by pursuing the proposed concepts/alternatives. Any constraints and assumptions that limit the viable concepts/alternatives to be pursued should be explicitly identified. These may change over time.
  - System Interrelationships. The CBA must consider all relevant systems and the effect they collectively will have in the prospective operational environment.
  - Multi-Role Systems. A system/item may accomplish significantly different functions at different times. The CBA should account for flexibility of this nature.
  - Benefits. Benefits should be defined to measure operational capabilities in terms of desired outcomes (e.g., lives saved, time saved). Benefits should be related to performance measures such that the effect of a change in performance can be related to a change in benefits.
  - Costs. Life cycle costs associated with each alternative being considered are to be identified in the CBA. The life cycle costs used in the CBA should be the same as those identified in the LCCE.
  - Cost-Benefits Comparisons. The results of the costs and benefits should be arrayed for each alternative to show the marginal changes. Uncertainties should be clearly identified in the analysis.
  - Sensitivity Analysis. Sensitivity analyses should also be conducted as appropriate to highlight the magnitude of effects resulting from realistic possible changes or uncertainties in key performance criteria, operational scenario, or other baseline parameters.

5.8 Develop HF/S Inputs to Procurement Documentation

5.8.1 Identify issues for RFPs

- Identify product characteristics which have invoked HF/S requirements specifications and document modifications
- Identify consistencies and trends in HF/S requirements specifications across product applications
- Identify HF/S issues
  - Personnel Availability Issues
    - Requirements and constraints on number of operating personnel
    - Requirements and constraints on number of maintenance personnel
    - Requirements and constraints on personnel workloads
    - Requirements and constraints on personnel workload distribution
    - Requirements and constraints on personnel selection
    - Requirements for manning
  - Personnel Utilization Issues
    - Constraints on personnel complement composition
    - Constraints on the role of man in system operation
    - Constraints on the role of man in system monitoring
    - Constraints on the role of man in system maintenance
    - Constraints on the role of man in system support
    - Constraints on the role of man in system setup
    - Requirements for automation
  - Personnel Capability Issues
    - Minimum skill level projection
    - Training requirements
    - Constraints on training overhead
    - Directed training decisions
    - Training effectiveness objectives
    - Constraints on training equipment and facilities
    - Requirements for special skills
    - Requirements for new skills
    - Constraints on the training pipeline
    - Requirements for embedded training
    - Requirements for computer assisted instruction
    - Requirements for cross training
    - Requirements for on-line tutorials/job performance aids
    - Requirements for decision aids
  - Personnel Performance Issues
    - Required levels of human performance
    - Requirements for sustained performance
    - Human performance objectives
    - Directed design decisions
    - System performance objectives which are expected to impact human performance
    - Information availability/quality constraints on human performance
    - Time constraints on human performance
    - Mission requirement constraints on human performance
    - Environmental constraints on human performance

    - Human capability constraints on human performance
    - System/equipment design constraints on human performance
    - Software design constraints on human performance
    - Procedural constraints on human performance
    - Operational constraints on human performance
    - Team performance requirements
    - Requirements for performance monitoring/measurement
    - Requirements for performance feedback
    - Duration of operation impact on performance
    - Mean time to repair estimate effects on maintainer performance
    - Mean time to perform preventive maintenance estimate effects on maintainer performance
  - <u>Personnel Safety & Health Issues</u>
    - Expected hazardous conditions
    - Directed design decisions
    - Mission requirement constraints on human safety and health
    - Environmental constraints on human safety and health
    - Human capability constraints on human safety and health
    - System/equipment constraints on human safety and health
    - Software constraints on human safety and health
    - Procedural constraints on human safety and health
    - Operational constraints on human safety and health
    - Biomedical constraints
    - Habitability constraints
    - Requirements for protective equipment
    - Requirements for warnings and alarms

5.8.2 Identify evaluation criteria

- Identify specific HF/S requirements expressed in the HF/S SOW, system specification, data reporting requirements, etc.
  - for workload reduction
  - for skill reduction
  - for workload reduction
  - for error reduction
  - for accident reduction
- State criteria within the context of analysis planning, integration, risk identification, and personnel requirements

5.8.3 Formulate HF/S inputs to solicitation documents

- Provide HF/S inputs to RFP preparation to be applied to the statement of work (SOW), that establishes what the Coast Guard wants to contractor to do in developing the system
- Provide HF/S inputs to RFP preparation to be applied to the system specification, that describes what the Coast Guard wants the product to do, under existing conditions and constraints
- Provide HF/S inputs to RFP preparation to be applied to the data requirements, which

is information the contractor is required to furnish the government

- Provide HF/S inputs to RFP preparation to be applied to the instructions to offerors, that provides guidance on writing a responsive proposal
- Provide HF/S inputs to RFP preparation to be applied to the proposal evaluation criteria, that explains to the offeror how the proposal will be evaluated by the Source Selection Evaluation Board

5.8.4 Provide criteria

- Assess HF/S evaluation criteria
- Prioritize criteria in the context of HF/S and system characteristics

5.8.5 Package HF/S inputs

- Integrate HF/S issues with HF/S evaluation criteria
- Submit inputs for procurement